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C-A OPERATIONS PROCEDURES MANUAL

14.3 C-A EMS Process Assessment for Beam Line Construction and Disassembly (AGS-002-EBC)

Text Pages 2 through 22

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 Collider-Accelerator Department Chairman Date

R. Karol

**BROOKHAVEN NATIONAL LABORATORY
PROCESS ASSESSMENT FORM**

I. General Information

Process ID:	AGS-002-EBC	PEP ID# 002		
Process Name:	Experimental Beam line Construction/Disassembly Operations			
Process Flow Diagrams:	AGS-002-EBC-01			
Process Description:	<p>This process includes the Experimental Beam line Construction / Disassembly Operations conducted within Buildings 901A, 912, 913, 914, 927, 930, 937, 949, 956 and RHIC IRs and managed by the Collider- Accelerator (C-A) Department at BNL. Particles are accelerated within the Booster, AGS and RHIC rings and then directed to various experimental target or collision points. The experimental beam lines terminate at specific experiments, which are maintained by the investigators. The experimental beam lines are constructed and disassembled, as required, in order to accommodate the particular experiments being conducted at that time. Experimental beam lines typically consist of the beam line and magnets; electrical equipment and vacuum pumps; magnet cooling system; and concrete and metal shielding. Unless damaged beyond repair, equipment and material are reused by the C-A Department for the construction of new beam lines. Section II and the above-referenced Process Flow Diagram provide more detail on the Experimental Beam line Construction/Disassembly Operations.</p>			
Dept./Div.:	Collider-Accelerator Department			
Dept. Code:	AD			
Building(s):	912, 927, 949, 956 and IRs at RHIC, 913, 914, 901A, 930, 937			
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Initial Release Date:	10/12/00			

II. Detailed Process Descriptions and Waste Determination

Background

Presently, the C-A Department has a major nuclear physics program, the focus of which is the Relativistic Heavy Ion Collider (RHIC) that operates to study nuclear phenomena in heavy ion and polarized proton collisions. The RHIC has three experimental areas where ion beams collide: PHENIX, STAR and BRAHMS. The 10 o'clock intersection region (IR) housed the PHOBOS experiment from 1999 through 2005 and the 12 o'clock IR houses the polarized jet target used to accurately measure the amount of proton polarization. However, the RHIC facilities are, in fact, the terminus of a complex of other accelerators and beam transfer equipment that also have experimental programs.

Located in the north central portion of BNL, the Collider-Accelerator Department is composed of seven accelerator physics machines including two Tandem Van de Graaffs (TVDGs), Linac, Booster, Alternating Gradient Synchrotron (AGS) and 2 rings in the Relativistic Heavy Ion Collider (RHIC). The TVDGs, Linac and Booster are considered pre-accelerators although they each have fixed-target experimental programs. The TVDG and Linac supply low to medium energy particles to the Booster, which in turn accelerates and directs beam to AGS. The AGS is the heart of the high-energy system and it is utilized to produce or accelerate high-energy protons, polarized protons and heavy ions for use in various high-energy high-intensity experiments developed to study the fundamental characteristics of matter.

The TVDG has two experimental halls for applied nuclear physics research. The Linac supplies beam to fixed targets in the Brookhaven Linear Isotope Producer, BLIP, which produces medical radioisotopes. The Booster supplies beam to fixed targets in the NASA Space Radiation Laboratory (NSRL), an experimental area that is used for space-radiation research. Although not currently scheduled for use, two major experimental areas extend off the AGS: the slow extracted-beam (SEB) experimental area, and the fast-extracted-beam (FEB) experimental area, which are used for high-energy physics and proton radiography research.

The experimental beam line construction and disassembly operations are associated with all experimental areas. The most active areas at this time are located within Building 912 (A-, B-, C- and D-lines), Building 927 (U- and V-line), Building 956 (NSRL), Building 937 (REF line), and RHIC IRs. These construction/disassembly operations have been organized into one major processing unit, identified as 1.0. Currently under construction in Building 912 is a development project, using an electron beam in an energy recovery LINAC (ERL) for future use at RHIC. Process Flow Diagram [AGS-002-EBC-01](#) graphically depicts the process inputs and outputs for the Experimental Beam line Construction / Disassembly Operations.

Fixed target experimental beam-lines terminate at specific experiment stations, which are maintained by the investigators. The experimental beam-lines into these target areas are constructed and disassembled, as required, in order to accommodate the particular experiments being conducted at that time. Experimental beam lines typically consist of the beam line and magnets; electrical equipment and vacuum pumps; magnet cooling system; and concrete and metal shielding. Unless damaged beyond repair, equipment and material is reused for the construction of new beam lines. Equipment and material, which cannot be immediately reused,

is stored within C-A Department storage areas (e.g., Buildings 912, 918, 936, 974 and 1101) for reuse later.

Unlike fixed target facilities that become radioactive due to high-intensity beam pulses striking a target thousands of times per hour, the RHIC facility is not significantly radioactive since a few low-intensity beam pulses are re-circulated or “stored” for hours. RHIC is a 2.4-mile circumference accelerator and collider. The RHIC facility consists of a beam injection system, two superconducting storage rings, six experimental halls or intersection regions and a number of support buildings. Accelerated protons or heavy ions in counter-rotating beams, each in separate rings, are brought into collision at up to four different experimental halls where large detectors are located. Various instruments to study nuclear phenomena in detail record the particle cascade produced by the colliding beams.

Over the last decade, the Collider-Accelerator Department has generated an annual average of 3500 to 5000 cu-ft of solid low-level radioactive waste. Recently, the fixed target high-intensity proton program in Building 912, which was supported by DOE, has terminated and significant waste management activities are needed to manage waste from this program. Thus, while the DOE program has ended, the average level of solid low-level radioactive waste output is expected to continue over the long-term; that is, through the next decade and beyond to place this area into a safe, stable state.

Routine operation of NSRL and RHIC produces industrial and hazardous waste and small amounts of low-level radioactive waste. Routine waste will continue to be produced from ongoing programs at TVDG, Booster and RHIC and associated transfer lines and experimental areas.

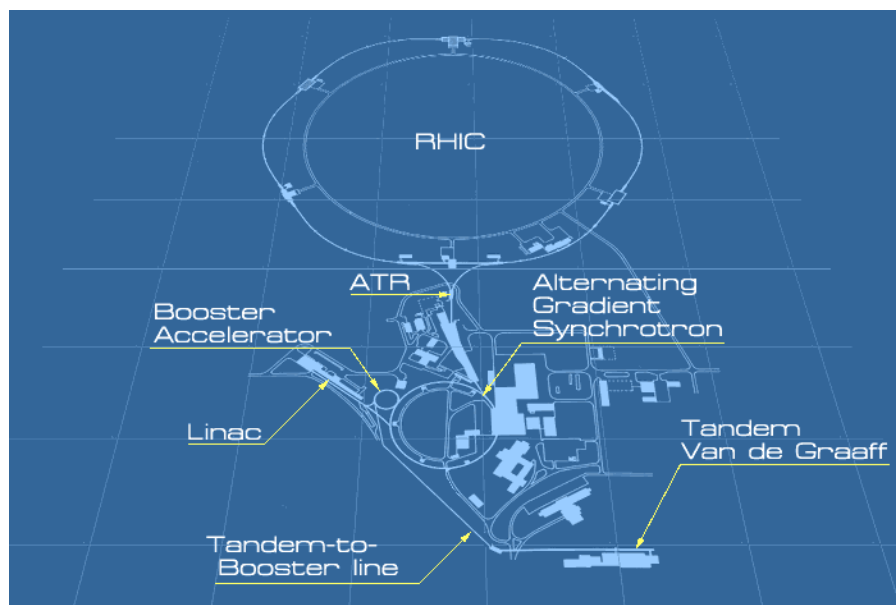


Figure 1 Overall Accelerator Complex.

Overview

Completed in 1970, the TVDG pre-injector facility was for many years the world's largest electrostatic accelerator facility. It can provide researchers with beams of more than 40 different types of ions that have been stripped of their electrons. Ions ranging from hydrogen to uranium are available. The facility consists of two 15 MeV accelerators, each about 75-feet long, aligned end-to-end. The Radiation Effects Testing and Calibration facility at TVDG is available for the study of space radiation effects, in particular, Single Event Upset (SEU) Testing and Spacecraft Instrument Calibration. The ion energies may range from 29 MeV protons to 385 MeV uranium ions. Ion irradiation and implantation are also available for other ion-beam related applications. Heavy-ion research for nuclear physics was started at the TVDG in 1970. Since 1986, at least one of the accelerators has served as the heavy ion injector for the Booster or AGS. In 1999, heavy ions from the TVDG were transported through the Booster and AGS and into the Relativistic Heavy Ion Collider. Since 2003, TVDG has served as an injector to Booster for supplying protons and heavy ion beams that are extracted from the Booster into the NASA Space Radiation Laboratory (NSRL). The NSRL radiobiology research program is related to the investigation of space radiation on humans and is particularly important for the planning of future long-term deep space flights.

To study heavy-ion collisions at high energies, a 2700-foot tunnel and beam transport system called the Tandem to Booster (TtB) Line was completed in 1991, allowing the delivery of protons and heavy ions from TVDG to the Booster for further acceleration. This line was an extension of the former Heavy Ion Transfer Line (HITL) that allowed for direct injection of heavy ions from TVDG into AGS. The HITL transport system no longer exists; however, the spur tunnel leading directly to AGS is still present. The TtB tunnel was constructed to extend the transport of protons and heavy ions from the Tandem to the Booster because the excellent vacuum levels in the Booster allow partially stripped ions heavier than sulfur to be accelerated to intermediate energies and then fully stripped before AGS injection. This feature ultimately allowed heavy ions of all species to be injected into RHIC for colliding beam physics.

The 200-MeV Linac was designed and built in the late 1960's as a major upgrade to the AGS complex. The 200-MeV Linac's purpose is to provide accelerated high-intensity protons for use at AGS, polarized protons at RHIC, and high-intensity protons at a Medical Department facility known as the Brookhaven Linac Isotope Producer (BLIP). The Linac is capable of producing up to a 35-milliampere proton beam at energies up to 200 MeV for injection into the Booster or for the activation of targets at the BLIP. The BLIP targets are used by the Medical Department to produce radiopharmaceuticals for human studies.

Construction of the Booster was begun in 1986 and completed in 1991. The Booster is a circular accelerator with a circumference of 600 feet, one fourth of the AGS, and is at the north corner of the AGS near the 200-MeV Linac. It is used to pre-accelerate particles entering the AGS ring, increasing the intensity of the particle beams generated by the AGS. The Booster receives proton beams from the Linac and heavy ion beams from the TVDG. The Booster injects higher energy beams through a fast extraction port and beam transport line into the AGS. The Booster increases the proton flux in the AGS by a factor of four over that attainable by direct injection from Linac. It increases the polarized-proton flux by a factor of 20. Additionally, it allows higher mass ions to inject into the AGS, which is a key feature leading to the successful

operation of RHIC. During routine, high intensity proton operations, protons accelerate in the Booster at a flux of 6×10^{13} per second; that is, 1.5×10^{13} protons per pulse at 4 Hz, to energy of about 1.5 GeV. The pulse frequency can increase to 7.5 Hz, the proton energy can increase to about 2.1 GeV and the potential flux can be 1×10^{14} protons per second.

The Booster receives one pulse of heavy ions from the TVDG that it accelerates to energies between 0.3 and 1 GeV per nucleon with an acceleration cycle of about 1 second, before stripping the accelerated ions of most of the electrons and injection into the AGS. The flux and the energy of the beam depend on the mass and charge of the accelerated ion. The number of ions per second extends from 3×10^{11} for deuterons to 3×10^9 for gold. In general, for heavy ions the total number of nucleons per second is about 6×10^{11} at a maximum energy of about 1 GeV per nucleon.

The NASA Space Radiation Laboratory (NSRL) is an experimental facility designed to take advantage of heavy-ion beams from the Booster accelerator. This facility is used for radiation biology studies, which are of great importance to the future of manned space flight. Radiation fields encountered in space may cause adverse health effects in humans. These effects are of special concern for prolonged space missions beyond the earth's protective magnetic field. Before such missions can be undertaken, a much more detailed understanding of these effects is needed to plan for the effective protection of astronauts. The Brookhaven AGS Booster is an ideal accelerator for these studies due to the good overlap between the available ions and energies with those encountered in space. Heavy-ions originate in the TVDG and travel through TtB to Booster for acceleration to high energies. Energetic heavy-ion beams are then delivered to a shielded NSRL target room where various specimens are exposed.

Of particular concern are the radiation effects due to the heavy ion components of galactic cosmic rays. There is considerable uncertainty regarding the risks associated with the high dose rates that would be encountered in long-duration space flight. Many studies with cells, tissue and animals are required to obtain adequate estimates of radiation-associated risks to humans in space. Such studies are conducted under controlled conditions utilizing ion beams that originate from the Tandem Van de Graff accelerator. The AGS Booster accelerates the TVDG ions to energies that match those encountered in space. The resulting energetic heavy ion beams are then delivered to a shielded NSRL target room where various specimens will be exposed.

Since 1960, the Alternating Gradient Synchrotron (AGS) has been one of the world's premiere particle accelerators, well known for the three Nobel Prizes won because of research performed with the particle beams. The AGS name is derived from the concept of alternating gradient focusing, in which the field gradients of the accelerator's 240 magnets are successively alternated inward and outward, permitting particles to be propelled and focused in both the horizontal and vertical plane at the same time. The AGS is capable of accelerating 8×10^{13} protons (80 TP) with every pulse, and is available to accelerate heavy ions such as gold and iron. The AGS is used as an injector for the RHIC and as the final accelerator for high-intensity-proton fixed-target programs.

In AGS, protons and/or heavy ions are accelerated in small bunches separated in time, which is referred to as a "beam." Once the beam approaches the speed of light within the AGS

accelerator ring, it is released along one of two paths, which lead to either 1) the “switchyard,” or 2) the U-line, the g-2 experiment (V-line) and the RHIC ring. The beam released to the switchyard is split into four paths referred to as “primary beam lines” and denoted as A, B, C and D. The primary beam lines are directed toward a “primary target” which then splits the primary beam lines into secondary or experimental beam lines. At the terminus of each experimental beam line is the experiment station, which contains the equipment and instrumentation utilized for the particular experiment. There is approximately 6.2 miles of primary and experimental beam line associated with the C-A Department accelerators.

The experimental beam lines are constructed of sections of aluminum or steel pipe through which the beam travels. Vacuum pumps are utilized to evacuate the beam line to prevent collisions with air molecules. Electrical-powered, water-cooled magnets are utilized to contain and focus the beam. The primary beam lines and initial sections of the experimental beam lines are surrounded by concrete and metal shielding which forms a tunnel. Electricity is supplied to the magnets utilizing rectifiers and power supplies, which are located outside the shielding. Typical experimental areas are shown in Figures 2 and 3 (from very large to small).

Figure 2 PHENIX Experiment at RHIC

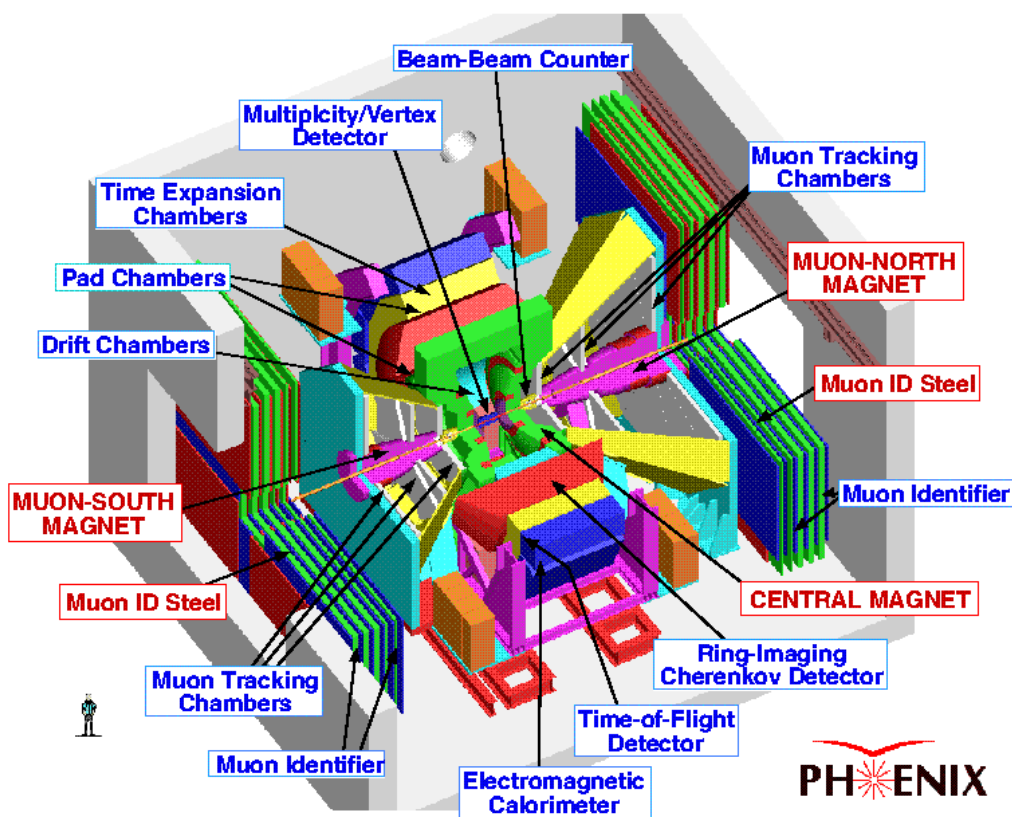
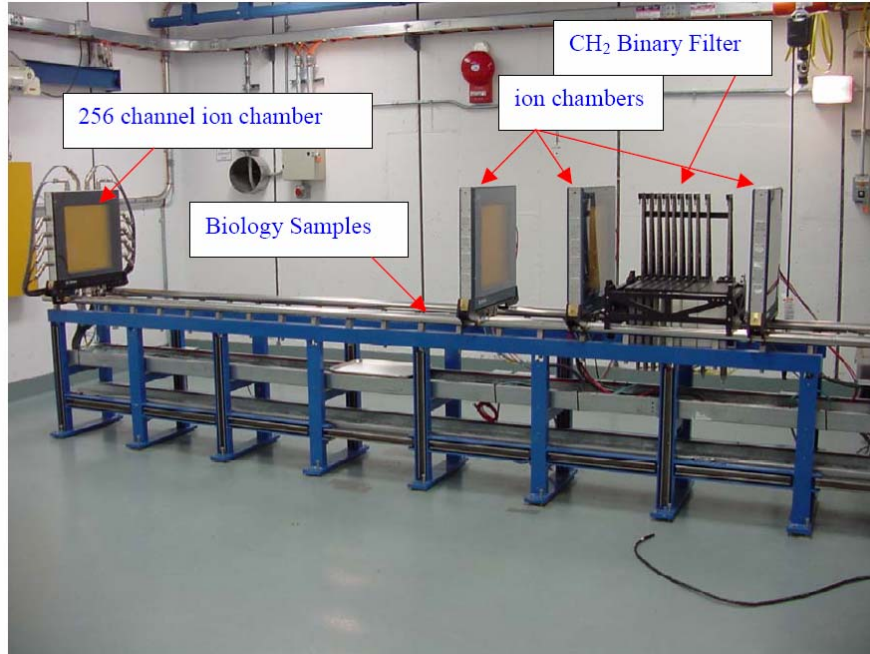


Figure 3 NSRL Experimental Area



The Experimental Support & Facilities (ES&F) Division of the C-A Department is responsible for beam line construction and disassembly operations. The Facilities and Experimental Support Group (FES) of ES&F coordinates the individual activities. The Beam Components and Instrumentation Group of the C-A Department is responsible for installing and maintaining the high voltage separators, beam instrumentation and beam splitters. In addition to C-A personnel, the Plant Engineering (PE) Department provides riggers, a rigging supervisor, carpenters, electricians and an electrical supervisor and the Central Shops Division (CSD) provides welders to support the C-A Department operations. A Project Engineer or Liaison Engineer oversees the entire construction/disassembly project. Each beam line is assigned a liaison engineer and a liaison physicist to work with the Project Engineer to coordinate and supervise construction/disassembly activities. In total, 45 to 50 workers are utilized to perform beam line construction/disassembly operations.

Construction Activities

The C-A Department constructs the experimental beam line to the proposed experiment station and the investigators install or participate in the installation of experimental detectors and instrumentation. Experimental beam line construction includes the following: installation and welding of beam line piping; placement of magnets; connection of magnet cooling system hoses and piping; installation and wiring of electrical equipment; installation of vacuum pumps; and the placement of concrete and metal shielding, as required. Design drawings are prepared by the investigators, which specify the type and location of equipment required for the experiment station. The C-A Department assists with the rigging, survey, and the utilities needed to install experiment equipment and instrumentation.

Disassembly Activities

The investigators are responsible for disassembling the smaller experimental detectors and associated instrumentation. The C-A Department will disassemble large detectors and disassemble the experimental beam line leading to the former experiment station. Experimental beam line disassembly may be expedited to accommodate new experiments. However, an experimental beam line may remain in place if no experiment is scheduled for the existing beam line.

Experimental beam line disassembly involves the following: removal of concrete and metal shielding; disconnection and removal of electrical, cooling system and vacuum pump equipment; removal of the magnets; and disassembly of the beam line piping. All equipment and materials are surveyed for radioactivity prior to disassembly. A Radiation Work Permit is typically required for beam-line disassembly operations. Items such as wrapping the equipment prior to moving, setting the equipment on plastic, tenting the work area, personal protective equipment, HEPA vacuums, waste containment, disposal procedures, etc. are outlined in detail on the Radiation Work Permit. Some materials and equipment require a “cool-down” period before they can be worked on. These items are surrounded by shielding and stored during the “cool-down” period. All shielding that is removed from the beam lines above 50 micro-R is stored in a radiation storage building until it is needed for a new project.

Low-level radioactive waste from terminated operations includes collimators, magnets, horns, beam dumps, rf equipment, vacuum pipes, mass slits, absorbers, targets, target holders and instrumentation. It is noted that while activated, most shielding, building walls and building floors are re-cycled.

Work on high-level radioactive material or equipment is rarely performed and most work is performed on low-level material and equipment. The strategy for most high-level radioactive materials is to wait a year or two while they decay to low-levels before working on them. Scrap metal and waste generated during experimental beam line disassembly are surveyed for radioactivity to ensure proper disposal.

Waste Management

Due to the potential for material to become activated during operation with Linac, Booster, AGS and RHIC beams, all waste generated within the C-A Department, including regular trash, is surveyed for radioactivity prior to disposal. Any waste found to be radioactive is managed as radioactive waste or mixed waste depending upon whether it is also hazardous. BNL has implemented a policy for the management of radioactive and mixed waste, which outlines specific procedures and tests to be performed and followed for the management of the waste. The majority of radioactive waste generated by the C-A Department is low-level radioactive waste associated with experimental beam line disassembly.

Tools and equipment utilized by workers during construction/disassembly operations are surveyed for radioactivity prior to leaving the work area. The item is decontaminated, if possible, and then removed from the work area. If the item cannot be decontaminated, it is disposed of as radioactive waste or left within the work area for future use (not typical).

Containers are located outside radioactive materials work areas for the collection of non-radioactive waste generated during beam line operation and maintenance or construction/disassembly activities. A separate container is provided for wire and metals, which are sorted for reuse or off-site recycling. Oily rags are segregated for disposal as industrial waste. The C-A Department utilizes environmental friendly degreasers, such as 'Micro' (a detergent based cleaner) and LPS Cleaner/Degreaser. Prior to disposal, all waste is surveyed for radioactivity to verify non-radioactive. If radioactive, the waste is properly packaged according to BNL's Standards Based Management System (SBMS) requirements and typically sent off-site for disposal as radioactive waste. BNL manages the recycling of all non-radioactive scrap wire and metal generated by the C-A Department.

Low-level radioactive waste generated within the C-A Department is stored to the northeast of Building 919B in an area referred to as the Low-Level Radioactive Waste Staging area, or Ft. Apache. Small-sized low-level radioactive waste (e.g., personal protective equipment, gloves, rags, etc.) is placed within plastic bags at the point of generation and brought to the outdoor area where it is placed within waste bins. At the outdoor area, the bags are visually inspected, inventoried and then transferred to yellow radioactive waste bins pending off-site transportation and disposal. Large sized low-level radioactive waste (e.g., metal, etc.) is brought to the Low-Level Radioactive Waste Staging Area and placed in yellow radioactive waste bins pending off-site transportation and disposal. The C-A Department utilizes three sizes of yellow waste bins, B-12's (48 cubic feet), B-25's (96 cubic feet) and B-52's (312 cubic feet). Low-level radioactive waste is transported to the BNL Waste Management facility and eventually transported to an offsite waste burial facility.

Higher levels of radioactive waste (eg. targets) are stored on-site in pigs (lead-lined steel cylindrical containers), or concrete vaults within a radioactive materials storage area. Shielding may also be placed around larger items that do not fit in prefabricated containers. This higher-level radioactive waste remains in storage at BNL until it can be transported off-site.

Routine operation of the RHIC produces industrial and hazardous waste. At present RHIC produces 25,000 to 30000 lbs. of industrial waste and 400 to 500 lbs. of hazardous waste yearly. There is less than 100 cu-ft of low level radioactive waste produced from RHIC at this time, but this will increase as the number of beam stores per day and the number of ions per store increases over the years.

Table 1 shows the recent waste shipped from the BNL site that is attributable to C-A Department operations. The table reflects the slowing, terminating, extension and startup of various programs in the last five years, although only waste in the first nine months of 2003 is tabulated. In recent times, increases in low-level radioactive waste, mixed-waste and industrial waste reflect the beam-line disassembly work that resulted from the termination of the DOE fixed-target program in Building 912. This is expected to last for several more years and level off as the NSF program begins routine operation in Building 912.

Table 1, C-A Department Routine Waste

Solid Low-Level Waste Shipped	1999	2000	2001	2002	2003	2004	2005
Radioactive Waste (cu-ft)	624	1642	2719	1618	2287	2400	5200
Hazardous Waste (cu-ft)	16.1	91.4	32.4	87.4	67	200	27
Mixed Waste (cu-ft)	18.75	40.3	21.6	1400	32	35	225
Industrial Waste (cu-ft)	179.4	220.4	445.5	42000	429.5	700	28

Regulatory Determination of Process Outputs

1.0 Experimental Beam Line Construction/Disassembly Operations

The beam lines are composed of individual systems, which are constructed and disassembled based on the requirements for a particular experiment. Listed below are the major systems for the beam lines along with the equipment utilized and the operations typically performed during construction/disassembly activities.

Beam Lines

The beam lines are composed of aluminum or steel pipes through which the beam travels. The pipes along the primary beam lines and near the targets are activated by the beam, but those located along the secondary or experimental beam lines typically are not because the beam has less energy after hitting the targets. The experimental beam lines utilize magnets for containing and focusing the beam. During construction operations, the pipes are removed from storage (or new piping is purchased) and welded together to create a path to the experiment station. During disassembly operations, the sections of pipe are cut and stored in the C-A warehouse for future use following a “cooling off” period, if activated.

Various types of welding are performed during construction/disassembly operations including: arc welding vacuum flanges; aluminum and stainless steel pipe; and magnet stands. A smoke eater is operated during welding and cutting to collect and filter smoke and fumes generated during the welding and cutting operations. The filters within these smoke eaters are not typically replaced.

Slag is the solidified molten material generated by cutting metals utilizing a cutting torch. Following generation, slag is placed within 55-gallon drums and surveyed for radioactivity prior to disposal. All usable material generated during cutting operations is reused. Non-radioactive slag is collected with scrap metal for off-site recycling. Radioactive slag is disposed of as radioactive waste.

In addition to welding, soldering is performed utilizing soft solder (tin/lead) and silver solder to connect electrical wires to various pieces of equipment. During soldering operations, the smoke eaters are utilized to collect any fumes or smoke. Since all scraps of solder are used, waste is generally not generated during soldering operations.

Targets removed from the beam lines are typically stored on-site within Radioactive Materials Storage Areas.

Magnets

Magnets are utilized to contain, bend, split and focus the beam and are located within the walls of the accelerator ring as well as within sections of the beam lines. There are numerous magnets maintained by the C-A Department, which utilize large amounts of electricity to create a strong magnetic field. Electrical cables attached to the magnets carry the electricity from the power supplies and rectifiers to the magnets. Due to the large amount of heat generated during use, a cooling water system is utilized to prevent the magnet from overheating.

During beam-line construction operations, the magnets are removed from storage or an inactive experimental beam line and mounted within their designated location. Cooling lines and electrical cables are attached to the magnets, run beneath the shielding walls (where required) and attached to the equipment. New magnets are not typically constructed for experimental beam lines.

During beam-line disassembly operations, the magnets are placed in storage for future use. Cooling lines are disconnected from the cooling manifold and electrical cables are disconnected from the rectifiers and power supplies. Any worn or broken magnet coils, wiring or cooling manifolds are removed from the magnets and replaced with new parts or parts from storage. All worn or broken parts are surveyed for radioactivity to ensure proper disposal. If a magnet is not immediately needed for a new experimental beam line, then it is stored for future use. Magnets, which may have become activated during use, depending on the location of the magnet, are placed in a radioactive materials storage area, covered with shielding and left to “cool-off,” i.e., decay-in-storage. If a magnet component is to be discarded, then it is disposed of as radioactive waste.

Experiment Stations

Experiment stations are located at the end of the experimental beam lines or at interaction regions in the accelerators, and are designed, constructed, maintained and disassembled by the investigator with assistance provided by the C-A Department. Experiment stations include detectors, instrumentation, data acquisition equipment and support systems. Experiment stations may also include magnets, power supplies to supply current to the magnet, PLC based controls and monitoring, bus systems to bring the power to the coils, and some experiments have hydraulic-based moving-systems for the magnets that contain 30 or more gallons of oil. The C-A Department typically assists the investigators with rigging and moving large pieces of equipment and shielding where required.

Nitrogen, carbon dioxide, helium, neon, xenon, argon, methane, ethane, isobutene, tetrafluoromethane and P-10 gases are some of the gases typically used in particle detectors. Nitrogen and carbon dioxide are stored as cryogenic liquids. Compressed inert gases such as carbon tetrafluoride, helium, neon and xenon are stored in cylinders. Separately the liquefied hydrocarbons, ethane, methane and isobutane, are stored in cylinders. The C-A Department assists in the installation and disassembly of gas storage areas, gas mixing houses and gas piping to particle detectors.

Wherever large particle detectors reside, there are a variety of safety systems. The main safety systems include fire, smoke, flammable gas and oxygen deficiency monitors. Some of these safety systems exist at up to three levels. The experimental areas are also serviced by HVAC systems that provide a continual fresh-air exchange, averting rising concentrations of leaked and locally vented gases. Emergency vent systems also exist and produce a high flow to dilute an airborne hazard. They are used to vent sudden, large gas leaks or smoke or may also be activated by the ODH alarm. The C-A Department assists in the installation, modification, replacement and disassembly of these safety systems.

Shielding

During operation of the beam, large amounts of radiation are produced when the beam is collimated or stopped or split; that is, divided between beam lines. Shielding is utilized to reduce or eliminate personnel and equipment exposure to radiation generated during beam operation. Shielding is required for the primary beam lines and target areas; however, it may not be required for the experimental beam lines.

Shielding for the beam lines is typically reused from previous beam lines. Shielding is constructed of concrete block, steel plates and less frequently, lead bricks or other materials. The shape, thickness and placement of the shielding are determined for each application. Shielding is stacked on the floor around and above the beam line creating what is referred to as a “tunnel.” Magnets, electrical cables, cooling-water lines, vacuums pumps and the beam line are located within the tunnel. The remainder of the support equipment is located outside the tunnel and is therefore shielded from radiation produced by the beam. Cooling lines and electrical cables run in trenches beneath the tunnel walls to connect equipment located outside the tunnel. Shielding is offset stacked so that the gaps between the materials do not align to create a path through which radiation could pass. Large overhead cranes located within the building are utilized to move the shielding. These cranes are maintained by the BNL Plant Engineering (PE) Division.

Concrete blocks utilized for shielding were historically fabricated off-site utilizing “heavy” concrete. Some new concrete shielding is fabricated on-site utilizing “light” 3,000-psi concrete. The shapes of the concrete blocks are designed for a particular location and use, and may be fabricated on-site. When not needed immediately for shielding, the concrete blocks are stored in the outdoor Block Yard located north of Building 912 for reuse later.

Large steel plates and, less frequently, lead bricks are utilized to provide shielding for the beam lines. While steel plates are utilized throughout, the lead bricks are used as a collimator (a device for reducing the beam size by eliminating beam halo). These materials are stored for future use when not immediately needed for shielding. The steel plates are stored in the outdoor Steel Yard located adjacent to the Block Yard north of Building 912.

Lead bricks are stored for later reuse. The lead shed is a small building located to the east of Building 912, see Figure 1. Figures 2 and 3 show the before and after photos of the lead shed. In 2003, all C-A legacy lead brick was shipped and buried; 167,000 lbs. was shipped. Lead remains in significant amounts in several beam lines and accelerators in the complex.



Figure 1 C-A lead storage shed.



Figure 2 Interior of lead storage shed prior to cleanup.



Figure 3 Interior of lead storage shed post cleanup.

Any steel not required for future use that has been surveyed and determined to be non-radioactive is stored in an outdoor area to the northwest of Building 912. This material is stored within this area until an outside contractor collects the steel for reuse or recycling. There is a storm drain in this area.

Because of soil contamination concerns, soil samples were taken on May 27, 1999 at the C-A Lead Plate Storage Area, the Brick Storage Shed and the Steel Storage Yard. Elevated levels of lead and chromium were noted in one of the samples at the Lead Plate Storage Shed. The contamination is located between the stacks of lead sheets and will be inaccessible until the plates are removed. The shed provides some containment for contaminants that might escape to the surrounding soil and minimizes the ability of rainwater to transport them further into the environment. Any future work performed in the area of the Lead Plate Storage Shed is reviewed

to determine if it will result in a release of the contaminants. If determined to be necessary, the soils will be remediated at the time that the lead plates are removed.

Electrical System

The beam-line electrical system consists of power supplies and rectifiers, which are utilized to supply D.C. electricity to the magnets. The equipment is located outside of the shielding and is wired to the magnets within the shielding tunnel.

Rectifiers are utilized to convert incoming alternating current (AC) to direct current (DC), which is utilized to power the magnets. There are approximately 400 rectifiers utilized by the AGS. Some rectifiers contain capacitors that utilize dielectric oil containing polychlorinated biphenyls (PCBs). All rectifiers containing PCBs have been inventoried and are affixed with large warning labels stating, "Caution Contains PCBs." All rectifiers, including those containing PCB capacitors, are checked for leaks prior to each run. Capacitors utilized by the rectifiers are rarely replaced. However, if replaced, the non-PCB capacitor would be disposed of as industrial waste and the PCB capacitor would be disposed of as hazardous waste.

Devices referred to as "beam separators" require a significantly larger amount of electricity to operate and therefore utilize much larger power supplies. The high-voltage beam-separator power supplies contain approximately 500 gallons of dielectric oil. Due to the expansion of the oil from the heat being dissipated, large surge tanks (referred to as "aardvarks" due to their shape) are attached to the power supplies to accommodate the oil's change in volume. The power supplies and aardvarks are located within secondary containment. Dielectric oil utilized by the power supplies is rarely replaced. However, if replaced, the oil would be disposed of as industrial waste.

Air drawn into the power supplies for additional cooling is passed through a filter to remove any particulates. These filters are replaced infrequently as part of system repair and maintenance. The filters are surveyed for radioactivity and in the past have been determined to be radioactive. The filters are radioactive due to the long period in service, large volume of air passed through the filters and proximity to the beam line and radioactive materials work areas. Periodic components within Power Supplies will fail. These components, whether singular or part of a printed circuit board assembly, are replaced. All components are surveyed for radioactivity and are disposed of based on results.

Cooling System

Beam-line magnets are cooled using a cooling water system (refer to the Process Evaluations for AGS and RHIC Cooling Water Systems). During beam line construction/disassembly operations, the cooling system hoses and piping are connected or disconnected between the magnets and cooling water supply system. The majority of the cooling lines are composed of reinforced rubber hoses connected to the individual pieces of equipment. These hoses are reused if in good condition. Worn hoses are surveyed for radioactivity and discarded in the regular trash, if not radioactive. Radioactive hoses would be disposed of as low-level radioactive waste.

Brass fittings are utilized to make connections between the reinforced rubber hoses and the cooling system manifolds or couplings on the equipment. These fittings are disconnected and

stored for future use if in good condition. Spent brass fittings are discarded as mixed waste because they are usually radioactive and brass contains a small amount of lead. Brass fittings, which are non-radioactive, would be discarded with scrap metal for off-site recycling.

Vacuum System

Vacuum pumps are utilized to evacuate the beam lines to prevent collisions of the beam with air molecules. The pumps are small capacity and typically contain less than 5 gallons of vacuum pump oil. Pumps located near floor drains are placed within secondary containment. Approximately half of the vacuum pumps are located within the beam line tunnels and half are located outside the tunnels depending on the available space. The oil within these pumps is replaced with new oil approximately once a year. The drained vacuum pump oil is kept separate from other used oil, as it may be radioactive depending on the vacuum pump location. The used vacuum pump oil is surveyed for radioactivity and is disposed of as industrial waste, if non-radioactive, or low-level radioactive waste. The vacuum pumps are removed and serviced in the mechanical shop located within the building. Servicing includes changing the oil and replacing seals, gaskets and any broken or worn parts. All waste is surveyed for radioactivity to determine the appropriate disposal method.

Experimental Areas

Trash containers are located outside of radioactive materials work areas throughout the experimental floor to collect waste generated during beam line and experiment operation, maintenance and construction/disassembly activities. Typically, two trash containers are placed next to each other, one to collect non-radioactive trash and the other to collect non-radioactive scrap wire and metal. When full, the contents of the containers are surveyed for radioactivity to verify non-radioactive. Radioactive trash and wire/metal is bagged and transported to the Low-Level Radioactive Waste Staging Area located to the northeast of Building 919B. Non-radioactive trash is discarded as regular trash and non-radioactive wire/metal is collected for off-site recycling, as allowed by DOE rules. BNL manages the recycling of non-radioactive scrap wire and metal.

Radioactive wastes (e.g., personal protective equipment, gloves, etc.) generated during beam line operation, maintenance, construction and disassembly activities are placed within appropriately labeled yellow bags. When full, these bags are “J-sealed” and brought to the Low-Level Radioactive Waste Staging Area for final packaging and off-site transportation and disposal as low-level radioactive waste.

Tools and equipment utilized by workers during construction/disassembly operations are surveyed for radioactivity prior to leaving the work area. The item is decontaminated, if possible, and then removed from the work area. If the item cannot be decontaminated, it is disposed of as radioactive waste or left within the work area for future use (not typical).

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
1.1	Scrap metal pipe from beam lines, welding slag, worn metal magnet parts, worn metal cooling system parts, worn metal vacuum pump parts, various scrap wire and metal	Non-hazardous/non-radioactive or radioactive material as determined by process knowledge/radioactivity survey	If non-radioactive, sent off-site for recycling; if radioactive, sent off-site as low-level radioactive waste	None
1.2	Targets	Non-hazardous/radioactive solid waste as determined by process knowledge/radioactivity survey	Waste is stored on-site in lead-lined pigs or concrete vaults	None
1.3	Soldering and welding fumes from the smoke eater exhaust	Non-hazardous/non-radioactive vapors as determined by process knowledge	Vapors are released to ambient room air	None
1.4	Smoke eater filters, worn non-metal magnet parts, worn non-metal cooling system parts, worn non-metal vacuum system parts, various trash	Non-hazardous/non-radioactive or radioactive solid waste as determined by process knowledge/radioactivity survey	If non-radioactive, discarded in trash; if radioactive, sent off-site as low-level radioactive waste	None
1.5	Non-PCB capacitors	Non-hazardous/non-radioactive solid waste as determined by process knowledge/radioactivity survey	Waste is transferred to the HWMF for disposal as industrial waste	None

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
1.6	PCB-containing capacitors	Hazardous/ non-radioactive solid waste as determined by process knowledge/ radioactivity survey	Waste is transferred to the HWMF for disposal as hazardous waste	None
1.7	Power supply air filters	Non-hazardous/ radioactive solid waste as determined by process knowledge/ radioactivity survey	If non-radioactive, discarded in trash; if radioactive, sent off-site as low-level radioactive waste	None
1.8	Electrical components from power supplies. (i.e. printed circuit boards)	Non-hazardous/ radioactive solid waste as determined by process knowledge/ radioactivity survey	If non-radioactive, discarded in trash; if radioactive, sent off-site as low-level radioactive waste	None
1.9	Vacuum pump oil	Non-hazardous/ non-radioactive or radioactive solid waste as determined by process knowledge/ radioactivity survey	If non-radioactive, transferred to the HWMF for disposal as industrial waste; if radioactive, sent off-site as low-level radioactive waste	None

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
1.10	Oily rags	Non-hazardous/ non-radioactive or radioactive solid waste as determined by process knowledge/ radioactivity survey	If non- radioactive, transferred to the HWMF for disposal as industrial waste; if radioactive, sent off-site as low-level radioactive waste	None
1.11	PPE, rags from radioactive materials work areas	Non-hazardous/ radioactive solid waste as determined by process knowledge/ radioactivity survey	Waste is sent off-site as low- level radioactive waste	None

III. Waste Minimization, Opportunities for Pollution Prevention

During the initial effort of baselining, the Collider-Accelerator Department processes for Pollution Prevention and Waste Minimization Opportunities each waste, effluent and emission were evaluated to determine if there were opportunities to reduce either the volume or toxicity of the waste stream. Consideration was given to substitute raw materials with less toxic or less hazardous materials, process changes, reuse or recycling of materials and/or wastes, and other initiatives. These actions are documented in this section of the original process evaluation. Action taken on each of the Pollution Prevention and Waste Minimization items identified can be found in the Environmental Services Division's PEP 2000 Database. Further identification of Pollution Prevention and Waste Minimization Opportunities will be made during an annual assessment of C-A processes. If any Pollution Prevention and Waste Minimization Opportunities are identified, they will be forwarded to the Environmental Services Division for tracking through the PEP Database.

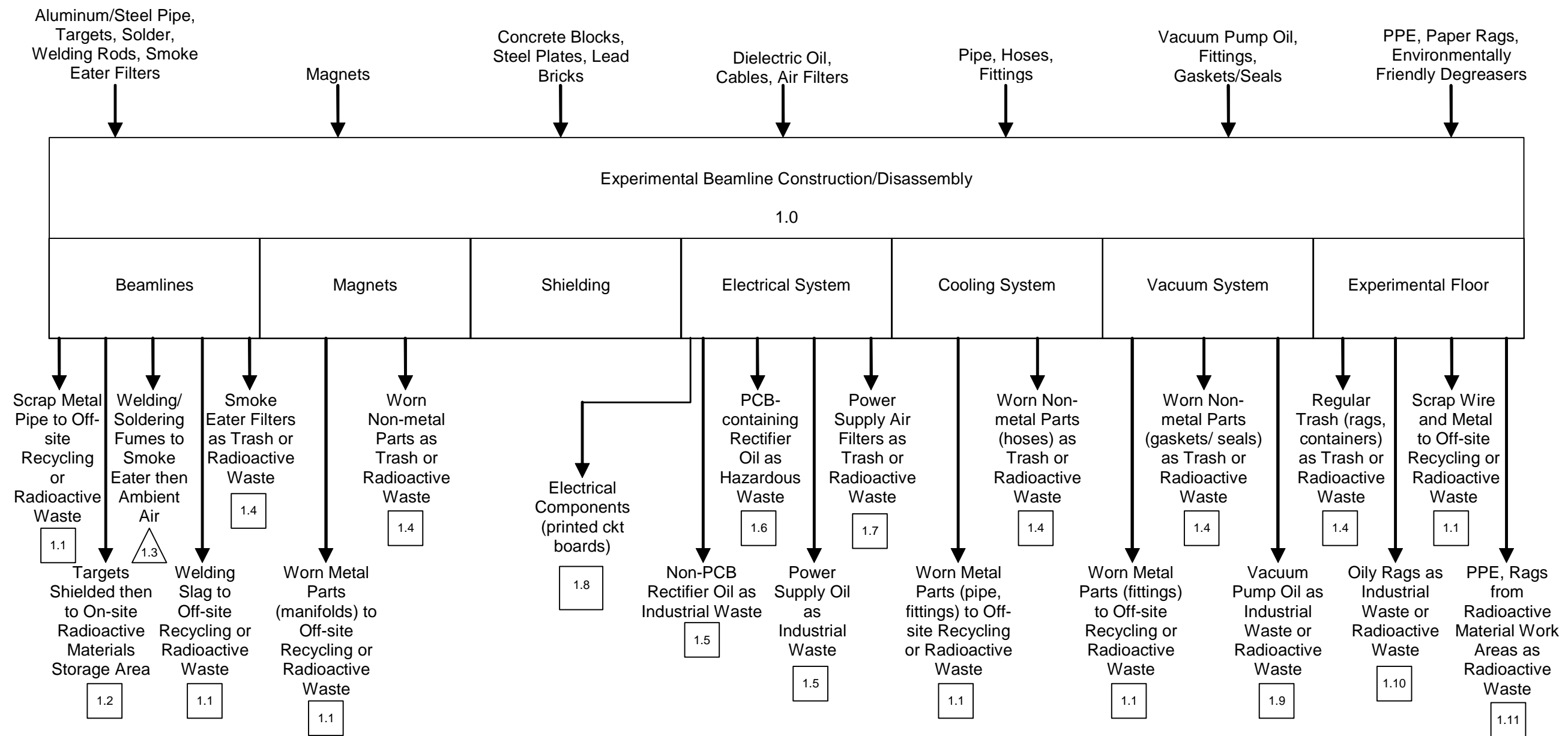
IV. Assessment Prevention and Control

During the initial effort of baselining the Collider-Accelerator Department Assessment, Prevention, and Control (APC) Measures for operations, experiments, and waste were described. These descriptions were generated if there was potential for equipment malfunction, deterioration, or operator error, and discharges or emissions that may cause or lead to releases of hazardous waste or pollutants to the environment or that potentially pose a threat to human health or the environment. A thorough assessment of these operations was made to determine if engineering controls were needed to control hazards; where documented standard operating procedures needed to be developed; where routine, objective, self-inspections by department

supervision and trained staff needed to be conducted and documented; and where any other vulnerability needed to be further evaluated. These actions are documented in this section of the original process evaluation. Action taken on each of the Assessment, Prevention and Control Measures can be found in the Environmental Services Division's PEP 2000 Database. Further identification of Assessment, Prevention and Control Measures will be made during an annual assessment of C-A processes. If any Assessment, Prevention and Control Measures are identified, they will be forwarded to the Environmental Services Division for tracking through the PEP Database.

ATTACHMENT 1

PROCESS FLOW DIAGRAM



Legend

□ Solid Waste

△ Air Emissions

○ Wastewater

SS = Sanitary Sewer

Filename: 002 Drawing.doc

BROOKHAVEN NATIONAL LABORATORY
 PROCESS ASSESSMENT PROGRAM

**Alternating Gradient Synchrotron - Experimental
 Beamline Construction/Disassembly Operations
 Process Flow Diagram**

AGS-002-EBC-01